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DISA

Instruction and Service Manual for Type 55D35 RMS Voltmeter

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OF

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DISA

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DANSK INDUSTRI SYNDIKAT A/S

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DISA

Instruction and Service Manual for Type 55D35 RMS Voltmeter

CHANGE INFORMATION

We at DISA constantly endeavor to keep up with the latest electronic developments by adding circuit and component improvements to our equipments as soon as they have been developed and tested.

Occasionally, due to printing and shipping requirements, we cannot immediately incorporate such changes in printed manuals. You may therefore find change information on loose sheets at the back of your manual.

HOW TO ORDER PARTS

Improvements are incorporated in DISA equipments as soon as they have left our laboratories. Therefore, when ordering a replacement part it is important to state its diagram designation in addition to the type number and serial number of the equipment plus a modification number where applicable.

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General Description

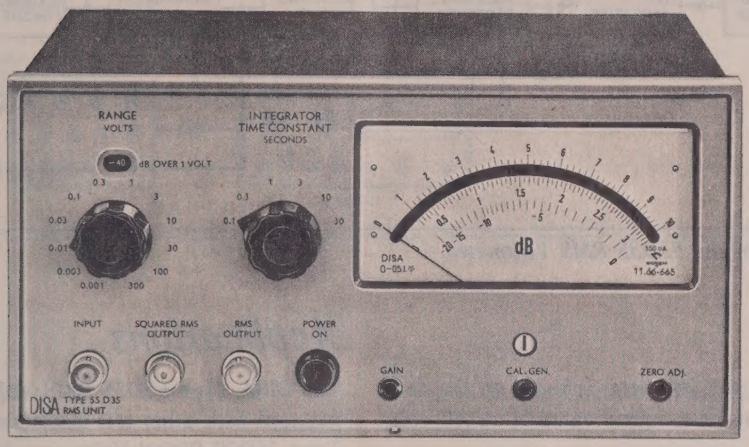


Fig. 1. The DISA Type 55D35 RMS Voltmeter.

Introduction

The DISA 55D35 All-transistor RMS Voltmeter is designed for measurement of the actual root-mean-square value of AC voltages between 300 μV and 300 $volts_{RMS}$, inside the frequency range 1 Hz to 400 kHz. These voltages may be sinusoidal or nonsinusoidal and have crest factors as high as 5 at full-scale deflection and 15 at one-third of full-scale deflection. The ability of the 55D35 Voltmeter to accept waveforms having such high crest factors ensures a high degree of accuracy, even in measurements of nonsinusoidal waveforms such as noise and pulse trains.

The front-panel terminals supply DC voltages proportional to the mean-square and root-mean-square values of the input signal.

The high stability and linearity of these DC voltages permit operation of accessory equipment such as X-Y recorders for permanent records or a digital voltmeter for high-resolution measurements.

The 55D35 RMS Voltmeter also permits varying the integrator time constant for best possible response time, depending on the waveform and frequency of the voltage under measurement. The time constant varies from 0.1 to 30 sec.

NOTE: In a new version of the 55D35 RMS Voltmeter, the Mark II, a voltage proportional to the squared value of the input signal is available at an output terminal on the rear panel.

NOTE:

The designation MARK I covers DISA RMS Voltmeters (Code No. 9055D0352) carrying serial numbers up to and including No. 462.

The designation MARK II covers DISA RMS Voltmeters (Code No. 9055D0353) carrying serial numbers higher than No. 462.

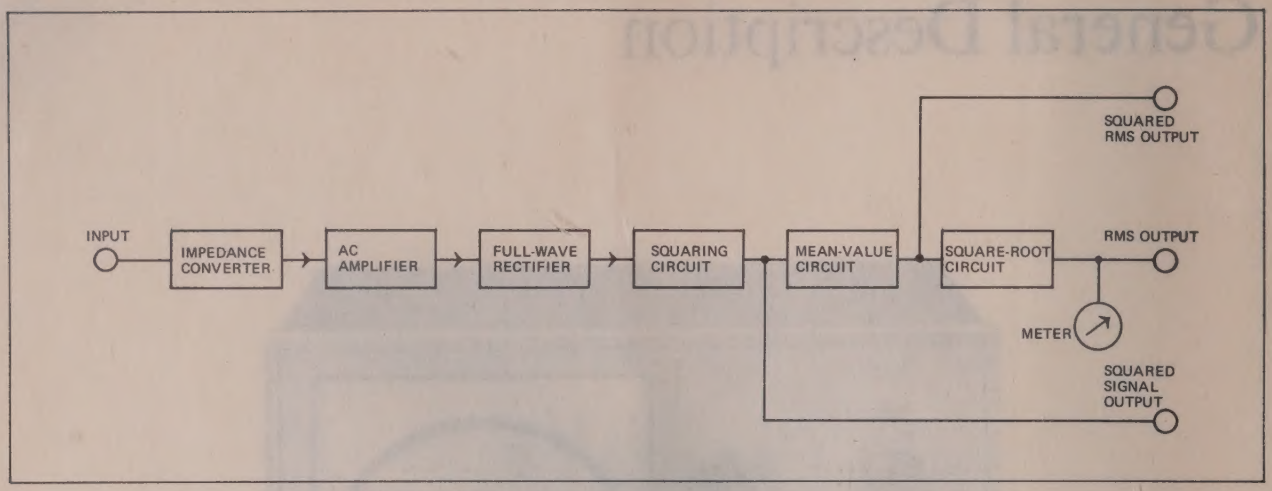


Fig. 2. Block diagram of the 55D35 RMS Voltmeter.

Principle

The principle underlying this voltmeter is based on the definition of the actual root-mean-square value of an AC voltage, e:

$$\sigma = \sqrt{\frac{1}{T}\int_0^T e^2 \, dt}$$

The block diagram shows the analog circuits performing the mathematical operations in accordance with the above equation. The signal under measurement is applied to the input attenuator. This is followed by an impedance converter, which is a unity-gain amplifier with high input impedance and low-impedance output to drive the second attenuator.

The output from the second attenuator is stepped up by an AC amplifier which has very stable gain due to heavy negative feedback. The amplified signal is full-wave rectified and amplified before it is applied to the squaring circuit, which handles positive signals only. The squaring circuit consists of a diode approximation to the parabola ensuring the dynamic range necessary for handling waveforms with large crest factors. The squared signal, available at a terminal on the rear panel, is applied to an integrator with variable time constant. The DC output voltage from the integrator is proportional to the mean-square value of the input signal and is available at a front panel terminal.

The DC voltage from the integrator is applied to a square root circuit providing current for the meter and a voltage for a front-panel terminal. Both current and voltage are proportional to the root-mean-square value of the input signal.

Applications

The DISA Type 55D35 RMS Voltmeter may be used in conjunction with other test instruments, for example the DISA Type 55D30 Digital Voltmeter, for measuring the RMS value of AC signals containing a DC component, for measuring RMS currents, for use as an AC-to-DC converter, and for measuring mean square voltage. The RMS Voltmeter Mark II may also be used as a squaring device for instantaneous squaring of AC signals.

RMS Voltage Measurements

Since it is an AC device, the 55D35 will measure only the RMS value (also termed the standard deviation) of the AC component of the signal. If the signal includes a DC component μ, this can be measured with a DISA Type 55D30 Digital Voltmeter, and the true RMS value then is:

$$e_{RMS} = \sqrt{\sigma^2 + \mu^2}$$

Measuring the RMS Value of Bandwidth Limited Random Signals

When measuring gaussian random signals, an error may be introduced which is a function of signal bandwidth and the integration time of the RMS Voltmeter.

For a gaussian random signal having a true mean value of $\mu = 0$, the normalized standard error of the RMS estimate is

$$\epsilon = \frac{1}{2}\sqrt{\frac{1}{BT\,(\frac{B}{2fo})}}$$

and the true integration time is:

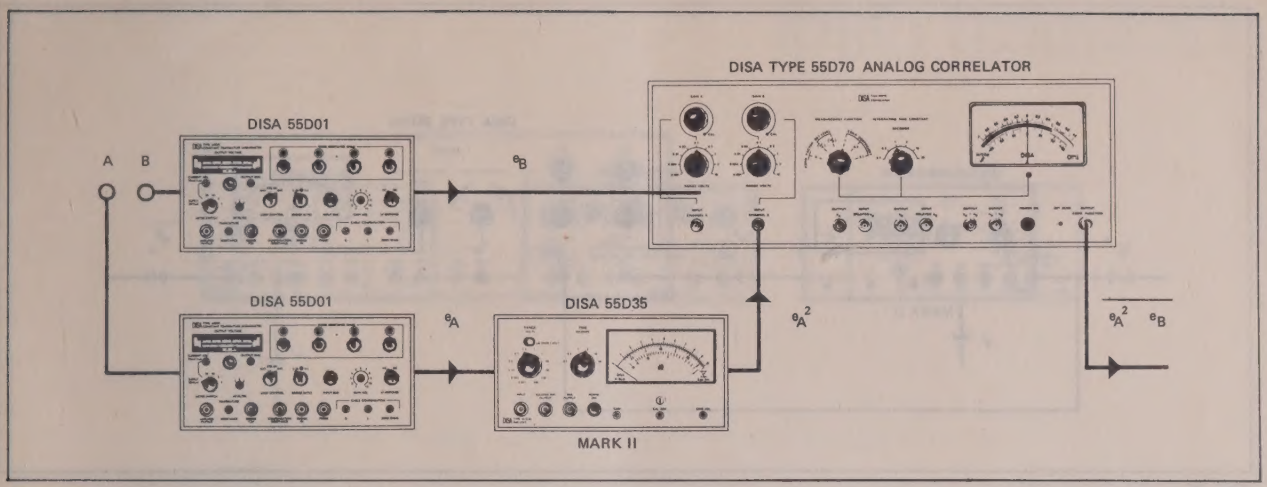


Fig. 3.

$$T = \frac{1}{4\,B\,(\frac{B}{2fo})}\;\frac{1}{\epsilon^2}$$

This gives the minimum true integration time in seconds required to achieve a desired error ϵ. B is the bandwidth in Hz, assuming a uniform power spectrum within B, and fo is the center frequency. For signals without a uniform power spectrum an "equivalent bandwidth" may be used.

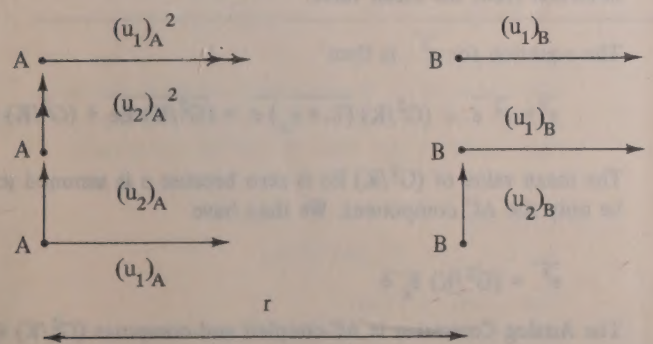
The corresponding RC integration time will be about twice that value.

Squaring of Signals

Some examples illustrating the use of the Type 55D35 Mark II as a squaring device are given below.

Triple Correlation Measurements

Measuring the triple velocity correlation in a turbulence flow field may be of interest. Here the triple-velocity-correlation coefficient can be expressed in terms of three specific correlation coefficients designated k(r,t), h(r,t), and q(r,t):



The three correlation coefficients are defined as follows:

$$k(r,t) = \frac{\overline{(u_1)_A^2\;(u_1)_B}}{u'^3}$$

$$h(r,t) = \frac{(u_2)_A^2\;(u_1)_B}{u'^3}$$

$$q(r,t) = \frac{(u_1)_A (u_2)_A\;(u_2)_B}{u'^3}$$

For homogeneous and isotropic turbulence it can be shown that a relationship exists between these three correlation coefficients, so that it is sufficient to measure only one of them.

The simplest one to measure is the longitudinal triple-correlation coefficient k(r). To do this, two hot-wires are placed parallel to each other, perpendicular to the main velocity U, and at a distance r in the main-flow direction. Let A and B denote the two points, and $(e)_A$ and $(e)_B$ the voltage fluctuations corresponding to the longitudinal turbulence components at A and B, respectively. Then

$$k(r) = \frac{e_A^2\;e_B}{e'^3}$$

where e' is the root-mean-square of the signal e.

From the equation it is seen that the signal of the wire at A has to be squared. This can be done by means of the 55D35 RMS Voltmeter Mark II. The setup is shown in Fig. 3.

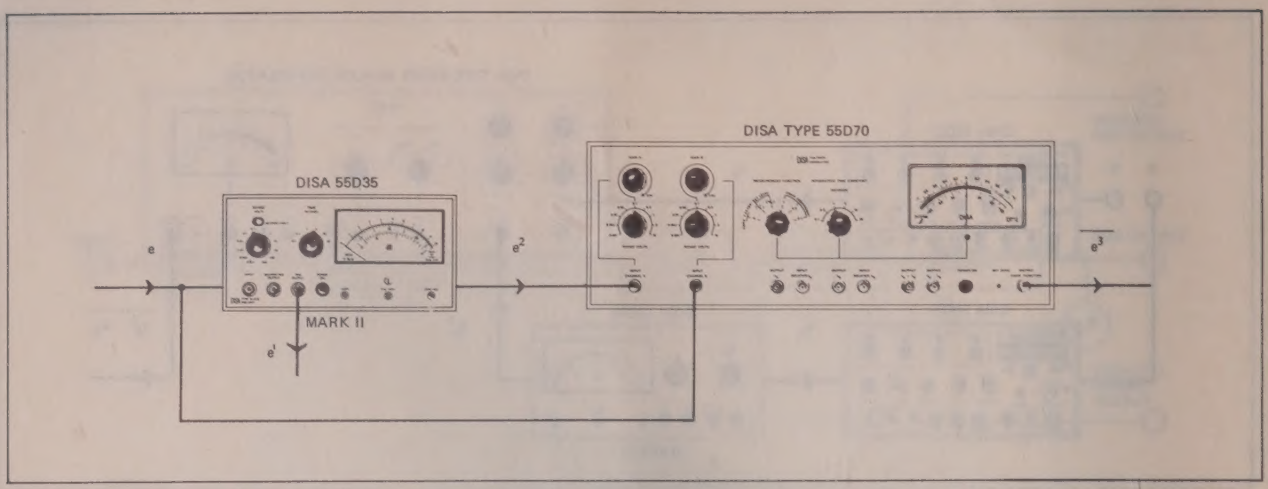


Fig. 4.

The operating procedure is:

a) Apply signal e_A to INPUT of 55D35 and turn RANGE switch to a meter deflection higher than one-third of f.s.d.

At the SQUARED SIGNAL OUTPUT an instantaneous voltage e_{SQ} is available:

$$e_{SQ} = K \left(\frac{e_{IN}}{G}\right)^2$$

where e_{IN} is the instantaneous value of the input signal measured from the mean value of the signal, and G is the RANGE switch setting.

As the RANGE switch is calibrated in 10 dB steps, the 3×10^n position has to be replaced by $\sqrt{10} \times 10^n$, where n = -3, -2, -1, 0, +1 and +2; e.g. for the RANGE switch in the 0.03 position, G is $0.01\sqrt{10} \sim 0.0316$.
K is a constant equal to 1/2 × 1/volt.
We then have

$$e_A^2 = e_{IN}^2 = (G^2/K) \times e_{SQ}$$

b) Apply the squared signal e_{SQ} to INPUT A and the signal e_B to INPUT B on the 55D70 Analog Correlator.

c) Operate the 55D70 as described in the instruction manual for the 55D70.

d) The triple correlation is now obtained as follows:

$$R_{AB} = G_A \times G_B \times R_{AB}'$$

$$= \overline{e_{SQ} \times e_B}$$

$$= (K/G^2) \times \overline{e_A^2 \times e_B}$$

$$\overline{e_A^2 \times e_B} = \frac{G_A \times G_B \times G^2}{K} \times R_{AB}' = 2G_A G_B G^2 \times R_{AB}'$$

To calculate k(r) it is necessary to measure the RMS value of e_A, which is the same as the RMS value of e_B, because the flow field is assumed to be homogeneous.

Moment Measurements

To characterize the amplitude properties of a random signal e (it can for example be a signal produced by a turbulent flow), such parameters as skewness factor, flatness factor and other higher-order moments can be used. Some setups for measuring these parameters are shown below.

Moment of 3rd Order (Skewness Factor)
The skewness factor for a variable e (it can be the velocity u in a turbulent flow) is defined as:

$$S \triangleq \frac{\overline{e^3}}{(\overline{e^2})^{3/2}} = \frac{\overline{e^3}}{e'^3}$$

$\overline{e^3}$ can be measured with the setup shown in Fig. 4.

The squared value of e can be written as

$$e^2 = (G^2/K)\, e_{SQ} = (G^2/K)\,(E + e_x)$$

where E is the mean value of e^2 and e_x is the instantaneous deviation from the mean value.

The equation for $\overline{e^3}$ is then

$$\overline{e^3} = \overline{e^2\, e} = (G^2/K)\,\overline{(E + e_x)\, e} = \overline{(G^2/K)\, Ee} + (G^2/K)\,\overline{e_x e}$$

The mean value of (G^2/K) Ee is zero because e is assumed to be only the AC component. We than have

$$\overline{e^3} = (G^2/K)\,\overline{e_x e}$$

The Analog Correlator is AC-coupled and computes $(G^2/K)\,\overline{e_x e}$

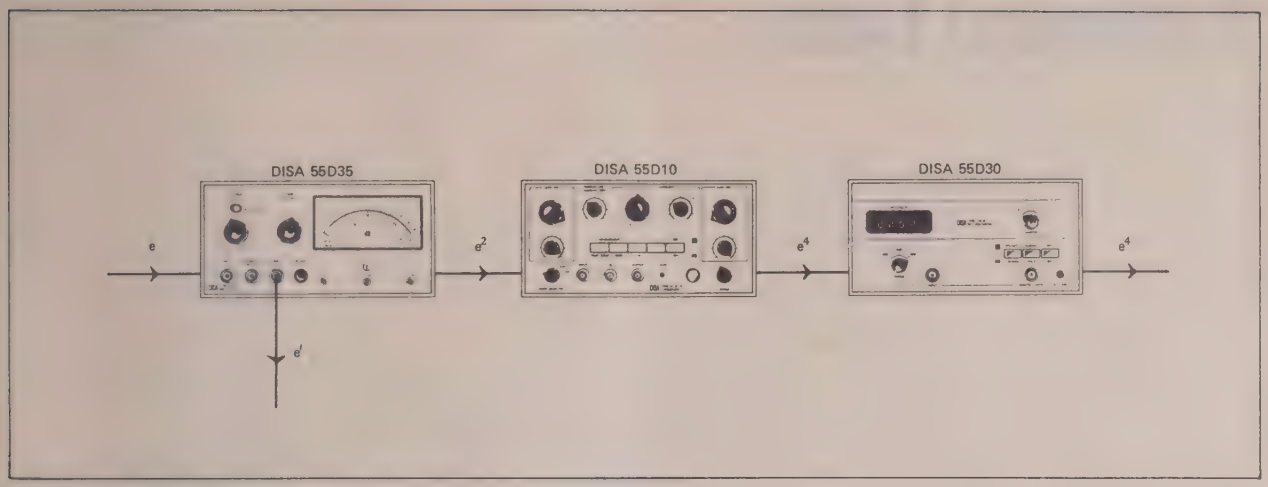


Fig. 5.

The measuring procedure is as described for triple correlation measurements and

$$S = \overline{e^3}/e'^3$$

is calculated from

$$\overline{e^3}/e'^3 = \frac{G_A\ G_B\ G^2 \times R_{AB}'}{K\ e'^3}$$

where e' is the RMS value of e.

Moment of 4th Order (Flatness Factor)

The flatness factor for a variable e is defined as

$$T \triangleq \frac{\overline{e^4}}{(\overline{e^2})^{4/2}} = \frac{\overline{e^4}}{e'^4}$$

Measurement of $\overline{e^4}$ can be performed as shown in Fig. 5.

The measuring procedure is as follows:

a) Operate the RMS Voltmeter as described for triple correlation measurements.

b) Adjust the 55D10 or 55D15 Linearizer for a transfer function:

$$e_{L\ out} = K_L\ e_{L_{in}}{}^2$$

and feed the output voltage from the SQUARED SIGNAL OUTPUT on the 55D35 to the input of the Linearizer.

c) Thereafter measure the mean value E of the output voltage of the Linearizer with the Digital voltmeter, and we then have:

$$E = K_1\ \overline{e^2_{Lin}} = K_1\ \overline{e^2_{SQ}}$$

$$= K_1\ (K^2/G^4)\ \overline{e^4}$$

$$T = e^4/e'^4 = (EG^4)/(K_1 K^2 e'^4)$$

where e' is the RMS value of e.

Special care must be taken not to overload the units when measuring higher-order moments.

Technical Data

Type 55D35 RMS Voltmeter MARK I

Full-scale Ranges:
1, 3, 10, 30, 100, 300 mV, and
1, 3, 10, 30, 100, 300 volts

Overload Capacity:
mV ranges up to ±100 volts, and
volts ranges up to ±400 volts input voltage

Input Impedance:
1 mV to 300 mV range:
1 MΩ shunted by approx. 30 pF

1 volt to 300 volts range:
1 MΩ shunted by approx. 10 pF

Attenuator Accuracy:
Better than ±0.2%

Frequency Range:
1 Hz to 400 kHz

Frequency Response (see also Fig. 6):
Flat within ±1% of full-scale value from 10 Hz to 100 kHz, ±7% of full-scale value from 1 Hz to 10 Hz and from 100 kHz to 400 kHz

Crest Factor:
5:1 at full-scale, inversely proportional to pointer deflection, e.g. 10:1 at half-scale deflection

RMS Output:
1 volt for f.s.d.

RMS Output Impedance:
Approx. 100Ω

Accuracy of RMS Output:
±1% of max. output voltage down to –15 dB
±5% of max. output voltage from –15 dB to –20 dB
(at mid-range frequencies)

Squared RMS Output:
–1 volt for f.s.d.

Squared RMS Output Impedance:
Approx. 1 kΩ

Accuracy of Squared RMS Output:
±1% of max. output voltage down to –30 dB,
±5% of max. output voltage from –30 dB to –40 dB
(at mid-range frequencies)

Meter Scales:
Volts 1 to 10 and 0.3 to 3
Decibels 0 to –20 dB over 1 volt
The meter indicates the RMS value

Accuracy of Meter:
0.5% of full-scale

Sensitivity Adjustment:
The instrument is supplied with a built-in reference voltage. The accuracy of the reference voltages is more than 5 times better than that of the instrument.

Time Constants:
0.1, 0.3, 1, 3, 10, and 30 sec

Mean-square Output:
Time to rise to 63% of final value of a step change.

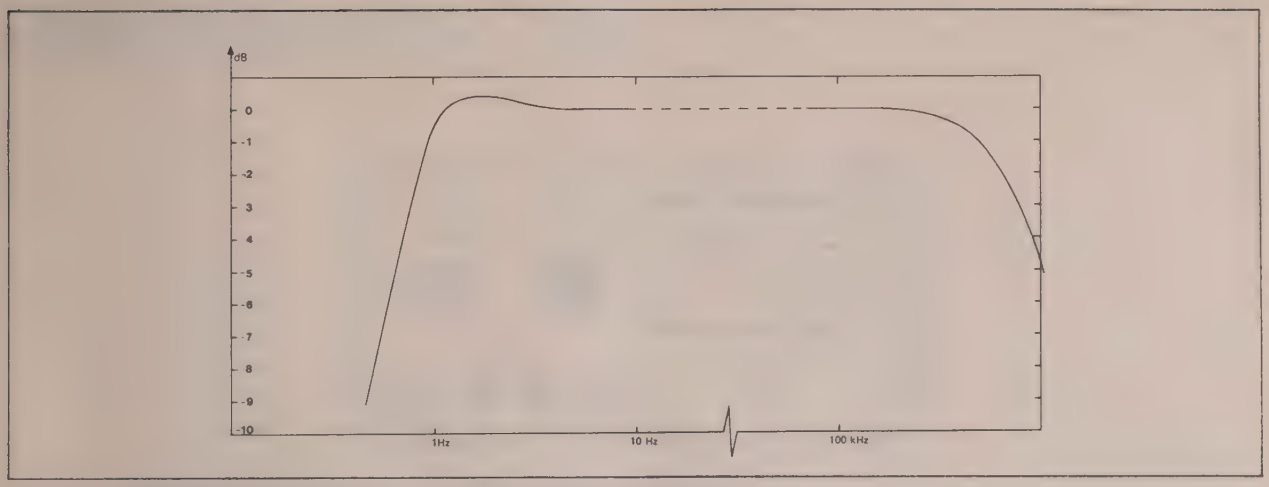


Fig. 6. Typical frequency response of Type 55D35 RMS Voltmeter.

99% of final value will be reached after approx. 4.6 times the above values.
Accuracy: 10%

Root-mean-square Output:
Time to rise to 63% of final value of a step change is 1/2 times the above values. 99% of final value will be reached after 2.3 times the above values.

Ambient Temperature:
0 to +45°C

Power Supply:
110/220 and 120/240 volts AC ±10%, 50 to 60 Hz

Fuse:
0.5 amp./110-120 volts and 0.25 amp./220-240 volts

Dimensions (HWD) in millimeters:
106 × 212 × 235

Finish:
Pastel green and light gray enamel

Weight:
3.5 kilos

Equipment Package:

The RMS Voltmeter is supplied with:

One power cable, 3 meters (without line plug)
(Code No. 9006A1781)

One input cable, 1 meter, BNC/BNC
(Code No. 9006A1861)

One output cable, 2 meters, BNC/Banana
(Code No. 9006A1851)

One instruction manual (English)
(Code No. 9150A2011)

We reserve the right to make, without notice, such changes in our published data as we may deem necessary or desirable.

Type 55D35 RMS Voltmeter MARK II

All specifications for the Mark II are the same as those of Type 55D35 RMS Voltmeter Mark I, with the following exceptions (the last figure of the code number indicates the Mark number):

Accuracy of RMS Output:

±1% of max. output voltage down to –15 dB
±2.5% of max. output voltage from –15 dB to –20 dB
(at mid-range frequencies)

Accuracy of Squared RMS Output:

±1% of max. output voltage down to –30 dB
±2.5% of max. output voltage from –30 dB to –40 dB
(at mid-range frequencies)

Instantaneous Squared Output:

Mean value is +0.5 volt DC for f.s.d.

Instantaneous Squared Output Impedance:

Approx. 1 kΩ R_{load} > 100 kΩ

Accuracy of Instantaneous Squared Output:

The accuracy of the mean value of the squared signal is the same as for Squared RMS Output

Line Voltage:

The instrument is designed for operation on any nominal line voltage within the ranges 100 - 129 and 200 - 259 volts AC, 50 or 60 Hz, and will tolerate voltage variations within the ranges 90 - 138 and 180 - 276 volts.

Line voltage selection is carried out by means of six plugs which fit into a 9-pin miniature socket on the back of the instrument. The proper plug is selected on the basis of the table below.

Plug Code No.	*Nominal Range, Volts *)*	*Max. Variations, Volts*
9052A1321	100 - 109	90 - 115
9052A1331	110 - 119	99 - 126
9052A1341	120 - 129	108 - 138
9052A1351	200 - 219	180 - 231
9052A1361	220 - 239	198 - 253
9052A1371	240 - 259	216 - 276

*) If your local line voltage differs permanently from the nominal value, the plugs should be selected accordingly.

Maximum permissible voltage variations – that is, deviations from the nominal voltage due to local conditions – are listed in the Table and, in parantheses, on the plug.

As shipped to you, the instrument is fitted with a plug for your local line voltage. However, all plugs are available at your DISA supplier.

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Instructions for Use

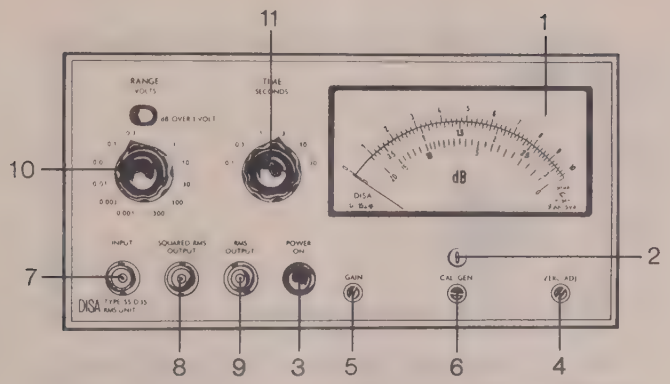


Fig. 7. Front panel of the Type 55D35 RMS Voltmeter.

Brief Description of Indicators, Controls, and Terminals

FRONT PANEL

(1) Direct-reading meter. Indicates RMS voltage level of input signal. The meter has two linear scales (the choice of scale depends on setting of RANGE switch) and a dB scale with 0 dB for f.s.d.

(2) Mechanical zero set screw: Screwdriver control for setting mechanical zero of direct-reading meter.

(3) POWER ON: Pilot lamp indicating when power is applied (power switch ON).

(4) ZERO ADJ.: Screwdriver control for adjusting electrical zero of RMS OUTPUT meter and direct-reading meter.

(5) GAIN: Screwdriver control for calibrating the meter by means of a calibration signal applied through the INPUT terminal.

(6) CAL.GEN.: When this pushbutton is depressed, an internally generated signal is applied to the AC amplifier, for calibration.

(7) INPUT terminal: BNC connector which enables application of an input signal to instrument measuring circuits.

(8) SQUARED RMS OUTPUT: BNC connector. This terminal carries –1 volt DC at f.s.d.; output is proportional to squared meter deflection. Output impedance is approx. 1000 Ω.

(9) RMS OUTPUT terminal: BNC connector. This terminal carries +1 volt DC at f.s.d.; output is proportional to meter deflection. Output impedance is approx. 100 Ω.

(10) RANGE switch: 12-position rotary switch which selects a number of attenuation ranges. The window designated "dB over 1 volt" indicates setting of RANGE switch in dB with 1 volt as zero reference. Each step of the RANGE switch either adds 10 dB to, or subtracts 10 dB from, a selected level.

(11) INTEGRATOR TIME CONSTANT: 6-position rotary switch which selects a number of time constants.

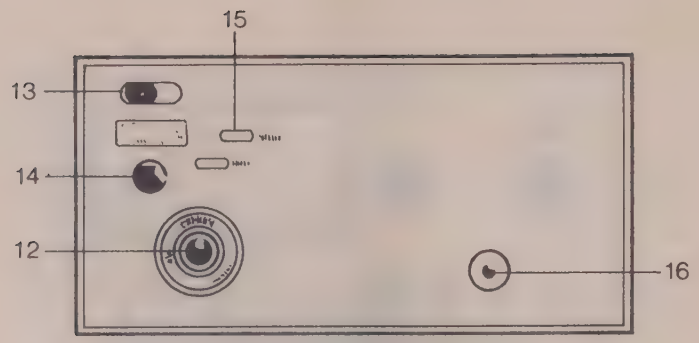


Fig. 8. Rear panel of the Type 55D35 RMS Voltmeter.

REAR PANEL

(12) POWER LINE: 3-pin connector socket for application of line voltage to instrument power-supply circuits.

(13) ON/OFF: 2-position power switch which applies 220 or 110 volts AC to instrument.

(14) FUSE: 110 volts/0.5 amp. or 220 volts/0.25 amp. fuse which provides protection against line-voltage surges.

(15) VOLTAGE SELECTOR: 110/220-volt switch which sets instrument to operate from either 110 or 220 volts AC.

(16) INSTANTANEOUS SQUARED OUTPUT: At this BNC terminal, the instantaneous value of the voltage is proportional to the squared value of the input voltage. For f.s.d. on the built-in meter, the mean value of the squared signal is 0.5 volt DC.

Note: The INSTANTANEOUS SQUARED OUTPUT *terminal is provided on instruments with serial numbers from 463 and up.*

Operating Procedure

Turn-on Procedure

To turn on the RMS Voltmeter, proceed as follows:

(a) Set the line-voltage selector (15) to the correct power line voltage as explained under Power Requirements.

(b) Set RANGE switch (10) at 300 volts.

(c) Apply power by plugging the power cable into the POWER LINE socket.

(d) Turn power switch (13) to ON; make sure that POWER ON pilot lamp lights.

(e) Before making any reading where high accuracy is important, the 55D35 RMS Voltmeter should be permitted to warm up for approx. half an hour.

Operating Procedure

(a) Attach test lead to INPUT terminal (7)

(b) Set RANGE switch (10) at 300 volts.

(c) Connect test lead to point of measurement.

(d) Rotate RANGE switch in a counterclockwise direction until direct-reading meter (1) shows reading in upper two-thirds of scale.

(e) Set the INTEGRATOR TIME CONSTANT switch for best possible response time, depending on waveform and frequency range of voltage under measurement.

(f) 1. The meter reading on the scale corresponding to the RANGE switch setting is proportional to the RMS value of the input signal.

2. Voltage at the RMS OUTPUT terminal (analog output) is proportional to the meter reading, being +1 volt DC for f.s.d.

3. Voltage at the SQUARED RMS OUTPUT terminal is proportional to the mean-square value of the input signal; it is –1 volt DC for f.s.d.

4. Voltage at the INSTANTANEOUS SQUARED OUTPUT terminal is proportional to the instantaneous squared value of the input signal; the mean value is 0.5 volt DC for f.s.d.

For high-resolution measurements use a digital voltmeter, such as the DISA Type 55D30 Digital Voltmeter, for measuring DC voltages at the BNC connectors.

Power Requirements

(For Mark II, see Technical Data)

The DISA Type 55D35 RMS Voltmeter is factory pre-switched for the line voltage specified. The RMS Voltmeter can be operated from any source of 110 volts, 120 volts, 220 volts, or 240 volts at 50 - 60 Hz. Nominal permissible line voltage variation is ±10%.

The RMS Voltmeter can be switched for the correct line voltage with the line-voltage selector on the rear panel. A slight modification is required where operation on 120 or 240 volts AC is desired.

Line Voltage 110 volts and 220 volts AC

To change from one line voltage to the other, remove the rear panel, which is fastened with four screws, and switch the line-voltage selector to the desired value, indicated in the VOLTS AC window when the rear panel is replaced. The AC line fuse for 110 volts is a slow-acting type rated at 0.5 amp. and 110 volts; for 220 volts it is likewise a

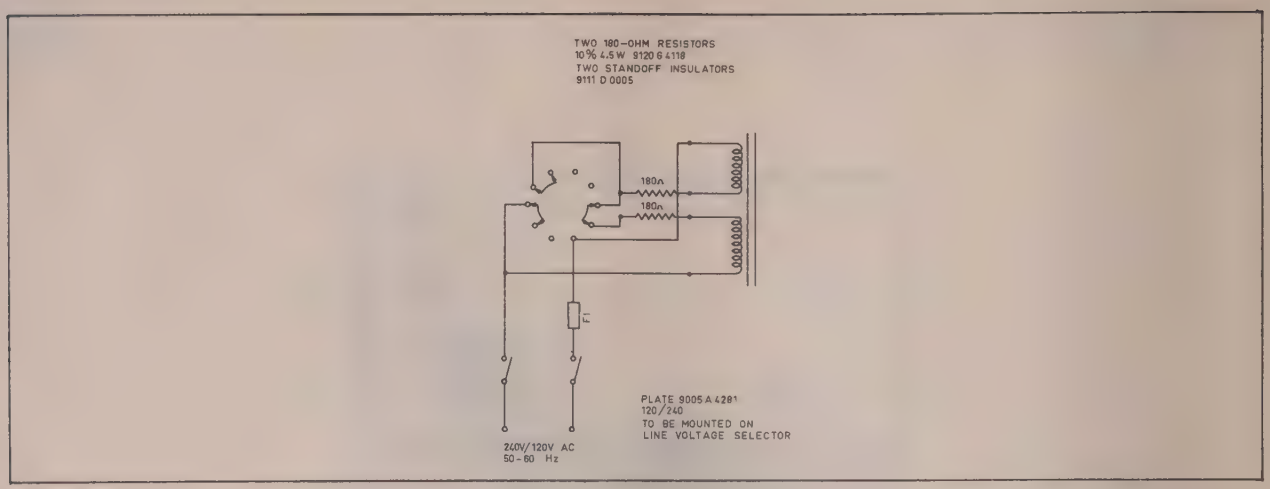


Fig. 9.

slow-acting type, and its ratings are 0.25 amp. and 220 volts. The fuse not in use is placed below the POWER LINE socket. The fuse rating is indicated in the AMP. SLOW window.

Line Voltage 120 volts and 240 volts AC

Changing to a line voltage of 120 or 240 volts AC requires a modification inside the instrument. This modification can be made at the factory if ordered.

The RMS Voltmeter can be switched to these line voltages as follows:

Remove the rear panel and take off the chassis. The back of the line-voltage selector is now accessible. Two resistors are inserted between the line transformer and pins 7 and 8 on the line-voltage selector as shown in the sketch below.

The resistors are mounted between two stand-off insulators and pins 7 and 8. After modification, the 110-volt position of the line-voltage selector will correspond to 120 volts and the 220-volt position to 240 volts. Fuses may be the same as those specified for 110 volts and 220 volts, respectively. Power consumption is approx. 12 VA.

Mechanical Installation

The DISA Type 55D35 RMS Voltmeter is a submodular unit suitable for table top operation. When used in combination with other submodular units, it can be mounted in a 19-inch rack as shown below.

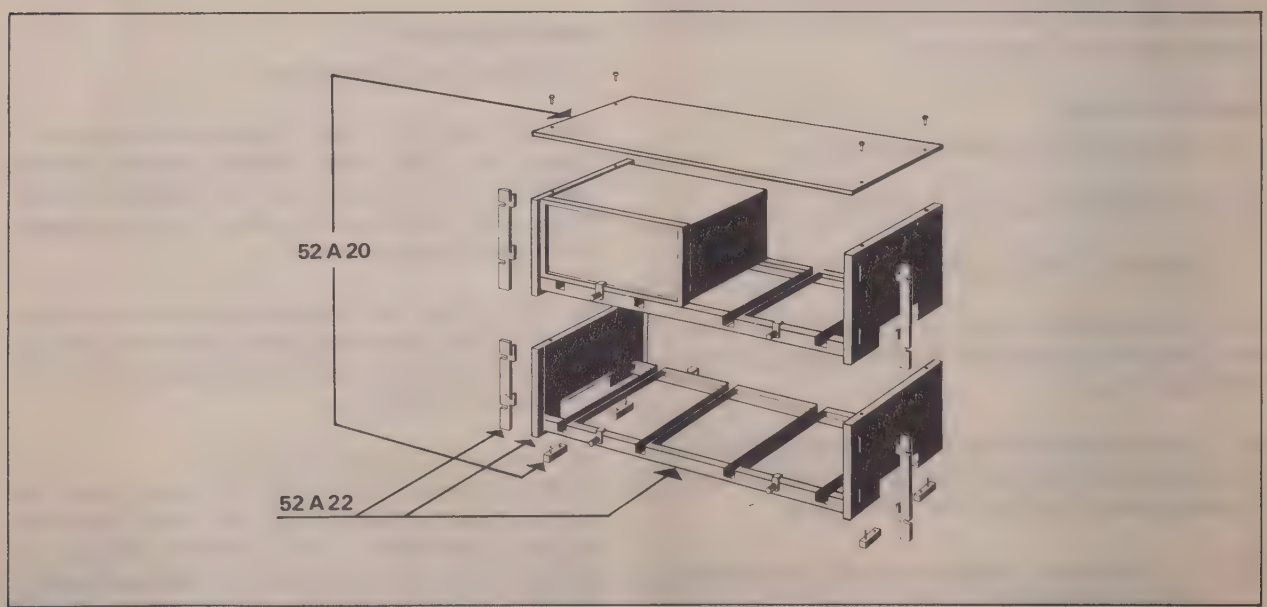


Fig. 10. Setup featuring two sets of 55A22 side walls with mounting hardware and one 55A20 top and bottom.

Service Instructions

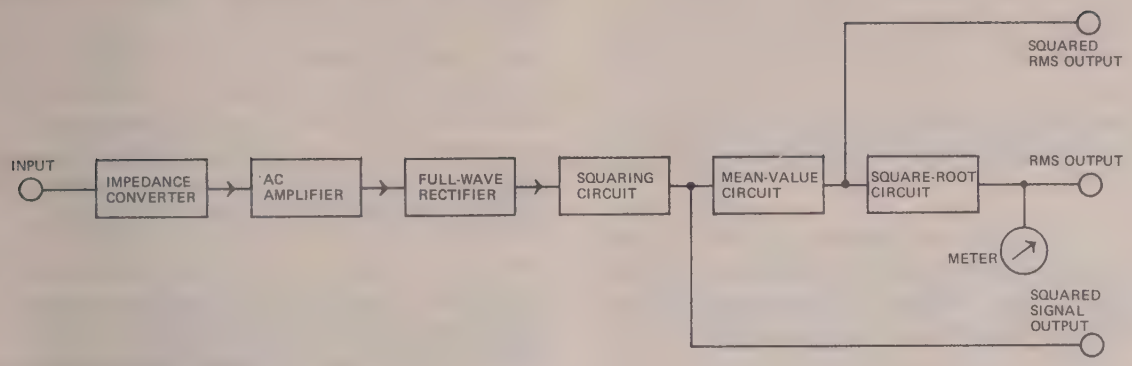


Fig. 11. Block diagram.

Circuit Description

GENERAL DESCRIPTION

The block diagram shows the analog circuits of the DISA Type 55D35 RMS Voltmeter.

The signal to be measured with the RMS Voltmeter is fed to the input attenuator through the INPUT terminal. The input attenuator has an input impedance of 1 MΩ and provides two ranges of attenuation. The output of the input attenuator is applied to an impedance converter, which is a non-inverting unity voltage gain amplifier. It presents a high impedance to the input signal and has low-impedance output to drive the second attenuator. The second attenuator provides six ranges in a 1-3-10 sequence. The two attenuators are switched to provide 12 ranges of attenuation.

The output of the second attenuator is stepped up by an AC amplifier which has very stable gain due to heavy negative feedback.

The amplified signal is full-wave rectified and amplified before it is applied to the squaring circuit, which handles positive signals only.

The squaring circuit consists of a twelve-diode approximation to the parabola, ensuring the dynamic range necessary for handling large-crest-factor waveforms.

The squared signal is applied to the SQUARED SIGNAL OUTPUT terminal and to an operational integrator having a variable time constant. The DC output voltage from the integrator is proportional to the mean-square value of the input signal and is available at a front-panel terminal. The DC voltage from the integrator is applied to a square root circuit which provides current for the meter and a voltage for a front-panel terminal. Both current and voltage are proportional to the root-mean-square value of the input signal.

DETAILED DESCRIPTION

Input Attenuator I (9055D4201) (Diagram No. 9055D687-)*
The input attenuator is a capacitance-compensated attenuator which handles two of the ranges provided by the twelve positions of the RANGE switch, S1.

For the six most sensitive settings of the RANGE switch – 0.001 volt to 0.3 volt – the output voltage of the attenuator is equal to its input voltage. For the six other settings – 1 volt to 300 volts – the input voltage is attenuated by a factor of 60 dB, corresponding to 1000 times, by the voltage divider consisting of R741 and R742. Trimmer C472 is set for 100 kHz.

Input impedance values are:

From 1 mV to 300 mV: 1 MΩ in parallel with approx. 25 pF
From 1 volt to 300 volts: 1 MΩ in parallel with approx. 10 pF

The resistors are high-stability 0.1% metal-film types.

Impedance Converter (9055D4011) (Diagram No. 9055D681-)
The input circuit of the impedance converter uses a field effect transistor in order to match the high-impedance level of the input attenuator to the low level of attenuator II. A field effect transistor in the input circuit makes it possible to accomplish an input resistance of 1 MΩ.

The AC signal for the impedance converter is RC coupled to the gate of field effect transistor C301, operating as a source follower, through R306 and C301. Current generator V302 operates as a resistance in the source circuit of V301. The bootstrap negative feedback from the source of V301 and R301 increases the effective resistance of R306 to input signals. This prevents R306 from imposing a load on the input signal.

**) Version figure of each diagram No. is replaced by a dash*

The compensating network between the drain of V301 and the base of V302 compensates for gain changes in V301. The impedance converter has a gain of 1.

Protective Circuit
Two diodes, D301 and D302, in series with resistors across the impedance converter input, limit the voltages applied to V301.

Resistor R303 and the small series resistors R304 and R301 limit the diode currents to permissible values with ±100 volts applied to the input. Limiting of the input signal will occur for values greater than approx. 4 $volts_{p-p}$, sine-wave.

Note that the protective circuit is required only in the six most sensitive ranges provided by the RANGE switch.

In the other ranges, the input attenuator reduces the input voltage to a permissible value, max. ±400 volts.

Second Attenuator, II (Diagram No. 9055D687-)
Attenuator II is a resistive divider which attenuates the AC input signal in steps of 10 dB from 0.3 volt to 0.001 volt. In all positions of the RANGE switch, attenuator II presents a low constant output resistance to the following amplifier stage.

High-stability 0.1% metal-film resistors are used.

Preamplifier (9055D4011) (Diagram No. 9055D681-)
The preamplifier is a stable-gain wideband amplifier. It is DC coupled in order not to introduce time constants. Its gain is controlled by the GAIN potentiometer, located on the front panel.

The AC signal from the output of attenuator II is applied to the base of V303, which is one-half of a balanced stage. The amplified signal appearing at the collector of V304 undergoes further amplification in V306 and C307; V307 moreover reduces the DC level to around 4 - 5 volts at the output. V308 ensures a low value of output impedance, while V305 functions as an impedance converter.

The gain level is determined by the resistance network composed of R327, R328 and R320, R321 as well as by feedback resistor R317 and the GAIN potentiometer on the front panel.

Resistance values have been selected with a view to providing stable operating points for the transistors. Overall gain is approx. 100.

Rectifier (9055D4051) (Diagram No. 9055D682-)
The rectifier consists of two operational amplifiers which are separated by a dual transistor, V406.

The first amplifier consists of a DC amplifier whose gain is determined by the ratio between R427 and R401//R402; from an AC point of view the gain is determined by the ratio between R414 and R401 or between R415 and R401 depending on the input signal since the two diodes, D401 and D402, are now part of the feedback network.

C402 serves the purpose of preventing any drift that might be introduced by the amplifier. This arrangement reduces the voltage drop in the forward direction across diodes D401 and D401, resulting in nearly ideal rectification.

The two half-wave signals across R414 and R415, respectively, are fed through dual transistor V406 to the inputs of a differential amplifier whose gain is determined by the ratio between R434 and R419 or between R420 and R418. R424 controls the differential amplifier output voltage and hence also the operating point of the following circuit, which is the squaring circuit. Maximum output signal at the differential amplifier is 40 $volts_{p-p}$; max. output signal is obtained at full-scale deflection and CF = 5.

Squaring Circuit (9055D4091) (Diagram No. 9055D683-)
The squaring circuit consists of the diode chain unit and a DC-to-DC converter which supplies the diode chain with a floating voltage of 30 volts.

The DC-to-DC converter changes a stabilized voltage of approx. +20 volts DC to a square-wave voltage and thereafter rectifies it. The rectified voltage across C501 is adjusted for 30 volts by means of R528. The RC network C505//C506 and R528 attenuates converter transients on the +20-volt supply voltage.

The square-wave voltage produced in the converter also serves as internal calibration voltage for the RMS meter. The square-wave voltage at the collector of V501 is additionally stabilized by reference diode D516. The voltage across D516 is stepped down by resistors R103, R108, and R102, located on the main circuit board. Potentiometer R102 controls the calibration voltage applied via switch S3 to preamplifier INPUT II when the built-in calibration generator is turned on by means of the CAL. GEN. control on the front panel.

The diode unit is composed of ten diodes (D502 - D511) and an associated biasing network the resistance values of which provide 3-dB separation between knee points.

The current through R525 and hence also the voltage across it follows, with approximation, the function $y = px^2$ for pos-

itive input signal; in other words, the voltage at the output is proportional to the square of the voltage applied to the diode chain input. Max. signal voltage at the output is approx. 16 volts$_{p-p}$. The output voltage is available at the SQUARED SIGNAL OUTPUT terminal.

Mean-value Amplifier (9055D4161) (Diagram No. 9055D685-) Integration of the diode-chain output signal is performed by an operational amplifier using a stepwise variable capacitance as the feedback element.

The amplifier, whose DC gain is determined by the ratio between R106 and R105//(~R101) on the main circuit board, is composed of two balanced amplifier stages followed by a single-ended amplifier stage and an emitter follower output stage.

R603 adjusts the base-to-emitter voltages of dual transistor V601 so that they are equal, in order to avoid temperature drift at the amplifier output.

The output is brought out to the front panel at the SQUARED RMS OUTPUT terminal. The voltage at the SQUARED RMS OUTPUT terminal, which is adjusted for zero voltage with R606 with no signal applied to the input, is stepped down by R107 and R109 on the main circuit board in order to obtain –1 volt DC for f.s.d. on the built-in meter.

The output impedance is largely determined by R107//R109. The integration time for the mean-value amplifier is determined by R101 and the capacitor which happens to be connected in the circuit by means of the INTEGRATOR TIME CONSTANT switch.

Time Constant Switch (9055D4221) (Diagram No. 9055D686-) The TIME CONSTANT switch permits selection of six different integration times from 0.1 sec to 30 sec depending on the combination of capacitors inserted in the circuit. The switch incorporates a function to discharge the last-used capacitor.

Square-root Circuit (9055D4121) (Diagram No. 9055D684-) The square-root circuit consists of an operational amplifier, the square-root unit, and an output stage. The operational amplifier gain is determined by the ratio between R808 and R801. The output level at the amplifier and hence also the reading of M1 are adjusted by altering the operating points of transistors V801 and V802 with the ZERO ADJ. potentiometer on the front panel (R2).

The output of the operational amplifier is fed to the diode chain consisting of four diodes with their associated biasing network.

Voltage at the diode-chain output follows (approximately) the function $y = p\sqrt{x}$ for positive input signals; in other words, voltage across the meter is directly proportional to the square root of the signal voltage at the emitter of V805. Meter sensitivity is adjusted with R817.

The output of the diode chain is applied, via emitter followers V806 and V807, to the RMS OUTPUT terminal on the front panel. R831 adjusts zero voltage at the RMS OUTPUT terminal, while potentiometer R829 is used to adjust the +1 volt DC output level for f.s.d. on the meter.

Power Supply (9055D3931 and 9055D3971) (Diagram Nos. 9055D679- and 9055D680-)

All circuits of the 55D35 are powered from stabilized supplies: +50 volts, +20 volts, and –20 volts.

The three supplies are identical, of the series regulator type.

The +20-volt supply uses V901 as a series regulator with V905, V904, V903, and V902 as amplifier elements which feed any change in output voltage back to V901, resulting in a highly stable output voltage.

The reference element is a temperature-compensated Zener diode, D902. Potentiometer R911 adjusts the stabilized voltage to the desired value.

The –20-volt supply is analogous to the +20-volt supply, and +50 volts is obtained by adding a +30-volt stabilized potential, adjustable with R961, to the +20-volt supply.

The entire power supply has been designed to handle power line variations of ±10% and includes provision for switching between different line voltages.

Maintenance

Test Equipment Recommended

DC voltmeter Accuracy: ±0.3% of full-scale	DISA Type 55D25 Digital Voltmeter
DC voltmeter 50 kΩ/volt Accuracy: ±1%	Siemens Multimeter
Voltmeter calibrator Accuracy: ±0.2%	Radiometer Type SNN 16 Sending Level Standard
Oscillator Min. frequency range: 1 Hz to 1 MHz	Wavetek
Attenuator Accuracy: ±0.5% Frequency range: DC to 300 kHz	DANBRIDGE

CHECKING THE DISA TYPE 55D35 RMS VOLTMETER BY MEANS OF THE BUILT-IN CALIBRATION GENERATOR

Before checking the instrument, allow a warm-up period of approx. half an hour, after which time the components will have reached proper working temperature.

(1) With line voltage switched off, adjust the mechanical zero of the meter with the slotted screw on the front panel directly below the meter.

(2) Apply power to the instrument and allow half an hour for it to warm up.

(3) With the INPUT terminal shorted, voltages at the outputs should be:

SQUARED RMS OUTPUT: 0 volt
RMS OUTPUT: 0 volt
METER OUTPUT: 0 volt
SQUARED SIGNAL OUTPUT: 0 volt

(4) Using the ZERO ADJ. front-panel control, adjust the zero of the meter connected at the RMS OUTPUT terminal.

(5) Remove the short circuit from the INPUT terminal and depress the CAL. GEN. button on the front panel.

(6) Voltages at the outputs should be:

SQUARED RMS OUTPUT: -1 volt
RMS OUTPUT: +1 volt

Meter output (f.s.d.):

SQUARED SIGNAL OUTPUT: +0.5 volt DC

(7) To calibrate the RMS meter, adjust the GAIN potentiometer on the front panel to output voltages within the specified limits with the CAL. GEN. button depressed.

The voltages listed above were measured with a DISA Type 55D25 Digital Voltmeter.

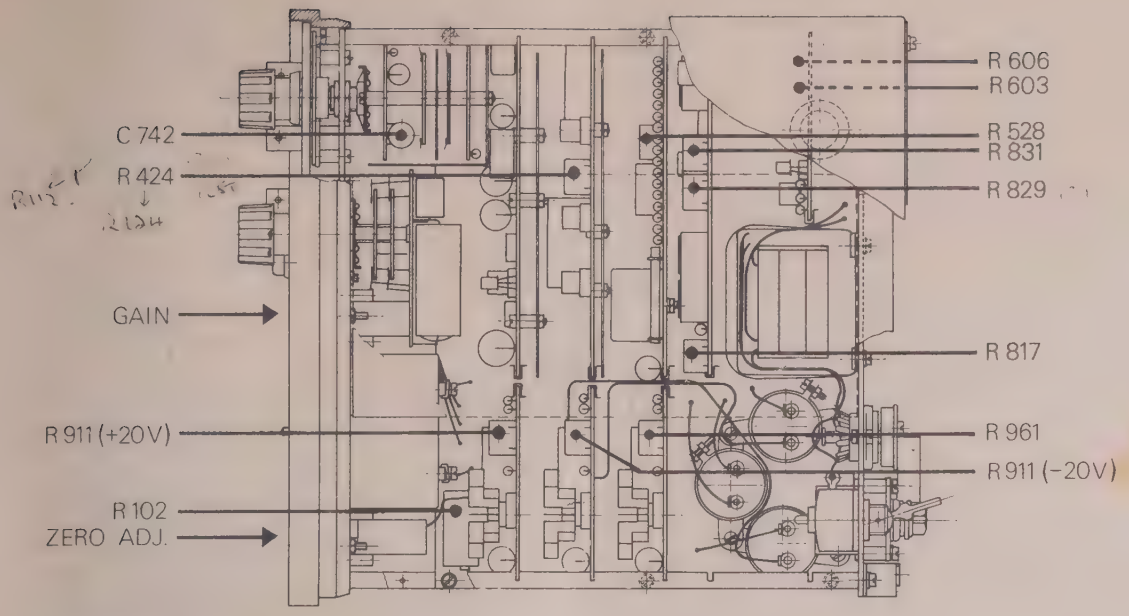


Fig. 12. Adjustment points.

ADJUSTING THE RMS VOLTMETER

Before making any electrical adjustments whatsoever, the instrument should be permitted to warm up for approx. one hour after which time the components will have reached proper working temperature.

When internal adjustments are necessary (at nominal line voltage), remove the four screws holding the rear wall and take off the housing. All adjustment controls are now accessible.

Zero Setting the Meter

The slotted screw for adjusting the mechanical zero of the meter is located on the front panel directly below the meter. If the meter pointer does not cover the zero line when line voltage has been removed from the meter for not less than one minute, the pointer should be brought into position by turning the slotted screw.

Adjusting and Checking the Power Supplies

Short-circuit the INPUT terminal on the front panel. Adjustment and checking of the power supplies should be performed in this order, after power has been applied to the instrument for approx. one hour:

1. *-20-volt Supply (9055D3931)*
On the under side of the main circuit board, connect a DC voltmeter and an oscilloscope between the -20 volt pin and chassis. Adjust potentiometer $R911_{-20}$ on the circuit board in question for -20 volts ±0.5%. Max. permissible line ripple is 500 μV_{p-p}.

2. *+20-volt Suppy (9055D3931)*
Connect the DC voltmeter and oscilloscope between the +20-volt pin on the main circuit board and chassis. Adjust $R911_{+20}$ on the circuit board in question for +20 volts ±0.5%. Line ripple must not exceed 500 μV_{p-p} in this case.

3. *+50-volt Supply (9055D3971)*
Adjust R961 on the circuit board in question for 50 volts ±0.5%. Max. permissible line ripple is 700 μV_{p-p}.

4. *30 Volts Floating (9055D4091)*
With a DC voltmeter connected across the two series-connected resistors R505 and R506, measure the floating voltage across the diode chain on the squaring-circuit circuit board. Adjust for 30 volts ±0.5% with potentiometer R528 on the circuit board.

Mean-value Amplifier (9055D4161)

Adjustment of potentiometer R606 and resistors R615, R604, and R605 will usually be required only after repair work has been performed on the amplifier. Adjustment, if necessary, is performed as follows:

1.
Connect the mean-value circuit to its associated terminal via an adaptor (service circuit board) so that the amplifier will be freely accessible. Remove the squaring circuit and ground the input of the mean-value circuit through 120 kΩ. Connect a DC voltmeter to the SQUARED RMS OUTPUT terminal.

2.
Short-circuit the collectors of dual input transistor V601 together and, if necessary, alter the value of R615 so that voltage at the output terminal is less than 2 volts. Remove short circuit.

3.
Short-circuit the emitters of dual input transistor V601 together; also short-circuit the bases of the same transistor together. Adjust potentiometer R606 for zero voltage at the SQUARED RMS OUTPUT terminal. If this cannot be done, resistor R604 and/or resistor R605 must be altered in value until it becomes possible. Remove the short circuit from

between the emitters and adjust potentiometer R603 for zero voltage at the SQUARED RMS OUTPUT terminal. If the control range of R603 is insufficient, a resistor must be inserted in series with the potentiometer, but this will not usually be necessary.

4.
Remove the short circuit from between the bases of V601 and the 120 kΩ resistor from the input of the mean-value circuit. Put the squaring circuit and the mean value circuit back in place on the main circuit board.

Calibrating the Squared RMS and RMS Outputs and the Built-in Meter

While performing these adjustments it is necessary to shield the RMS Voltmeter in order to avoid interference to adjustments on account of noise fields (it is suggested that a test housing, with holes for adjustment, be provided; this will also make it possible to obtain correct working temperatures inside the instrument at normal ambient temperature). Calibration may be performed by means of the built-in calibration generator (CAL. GEN.), or a known voltage may be applied through the INPUT terminal.

1. Calibration with the Built-in Generator (Cal. Gen.)

1.1 With the RANGE switch in the 0.3-volt position and the INTEGRATOR TIME CONSTANT switch in the 0.1-sec position, and with the INPUT terminal short-circuited, adjust R606 for zero voltage at the SQUARED RMS OUTPUT terminal.

1.2 Turn on the CAL. GEN. and adjust the GAIN control on the front panel for –1.000 volt at the SUQARED RMS OUTPUT terminal.

1.3 Turn off the CAL. GEN. and set the built-in meter to 0 volts , using the ZERO ADJ. screw.

1.4 Turn on the CAL. GEN. and adjust R817 on the square-root circuit board so that the built-in meter reads 0 dB.

1.5 Turn off the CAL. GEN. and adjust R831 for 0 volts at the RMS OUTPUT terminal.

1.6 Turn on the CAL. GEN. and adjust R829 for +1.000 volt at the RMS OUTPUT terminal.

1.7 Repeat the procedures described under 1.5 and 1.6 above, in that order, until you have zero voltage at the RMS OUTPUT terminal and a zero volts reading on the built-in meter, and until 0 dB on the meter corresponds to +1.000 volt at the RMS OUTPUT terminal.

2. Using an External Calibration Generator

This method also permits calibration of the built-in calibration generator. A DC voltmeter and a voltage calibrator are required, for instance a RADIOMETER Sending Level Standard, which can provide an output voltage of 275 mV_{RMS}.

With calibration voltage applied through the INPUT terminal, the RANGE switch should be set so that the corresponding built-in meter reads over two-thirds of f.s.d. The reading of the built-in meter is proportional to the RMS value of the signal fed through the INPUT terminal. The voltage at the RMS OUTPUT terminal is proportional to the meter reading, and the RMS OUTPUT voltage is +1.000 volt for f.s.d. The SQUARED RMS OUTPUT voltage is the squared value of the voltage at the RMS OUTPUT terminal with opposite sign.

The procedure for calibration with an RMS voltage of known value X (for example, 275 mV) and any frequency between 100 Hz and 10 kHz is as follows:

2.1 Set the INTEGRATION TIME CONSTANT switch at

0.1 sec. Set the RANGE switch so that, with the calibration voltage X (275 mV) applied, the built-in meter reads over two-thirds of f.s.d. With a calibration voltage of X the expected deflection is Y of f.s.d. (for X = 2.75 mV, Y is 2.75/3.16 = 0.869 ~ 0.87).

2.2 Short-circuit the INPUT terminal and adjust R606 for zero voltage at the SQUARED RMS OUTPUT terminal with a DC voltmeter connected to it.

2.3 Connect the calibration voltage X (275 mV) to the INPUT terminal.

2.4 Adjust the GAIN control on the front panel so that the voltage at the SQUARED RMS OUTPUT terminal is $-Y^2$ (-0.869^2 volt = –0.757 volt) measured with the DC meter.

2.5 Short-circuit the INPUT terminal and set the built-in meter for zero voltage, using the ZERO ADJ. screw.

2.6 Repeat 2.3 and adjust R817 so that the built-in meter reads Y X f.s.d. ($\frac{2.75 \times 3.16}{3.16}$ = 2.75 ~ 275 mV)

2.7 Short-circuit the INPUT terminal and adjust R381 for zero voltage at the RMS OUTPUT terminal.

2.8 Repeat the procedure described under 2.3 above and adjust R829 for a voltage of Y (+0.869) at the RMS OUTPUT terminal.

2.9 Repeat the procedures described under 2.7 and 2.8 above, in that order, until you have zero voltage at the RMS OUTPUT terminal and a zero volts reading on the meter of the 55D35, and until a 275-mV reading on the meter of the 55D35 corresponds to 870 mV at the RMS OUTPUT terminal.

Adjusting the Linearity

This requires an attenuator with 10 dB attenuation per step with an accuracy of ±0.5%, and an audio oscillator (or voltage calibrator).

1.
With the RANGE switch in the 0.3-volt position, feed a sine-wave signal at, say, 150 Hz through the INPUT terminal and increase its amplitude until you have 1.000 volt at the RMS OUTPUT terminal as measured with a DC voltmeter.

2.
Attenuate the signal by 10 dB, using an external attenuator. This should cause the voltage at the RMS OUTPUT terminal to drop to 316 mV. If it does not, the meter deflection should be adjusted, using R424 on the rectifier circuit board.

3.
Adjustments to R424 may affect the voltage at the SQUARED RMS OUTPUT terminal. The zero of this output should be adjusted with R606.

4.
Repeat the procedures described under 1.1, 1.2, and 1.3 above until correct stepwise attenuation has been accomplished. If correct attenuation cannot be accomplished within the control range of R424, you should replace R423 with a resistor of the nearest standard value. If the meter deflection is too low, R424 should be made higher – otherwise smaller.

5.
Since the voltage at the SQUARED RMS OUTPUT terminal is affected by adjustment of the 10 dB attenuation, it is necessary to repeat the procedures described under 1.1 and 1.2 above (alternatively 2.2 and 2.3 if a voltage calibrator is used).

Adjusting the Frequency Characteristic of the Attenuator

This requires an audio oscillator having a frequency characteristic that is linear to 100 kHz or higher.

1.
With the RANGE switch in the 1-volt position, apply a 1 kHz signal through the INPUT terminal and increase its amplitude until the built-in meter reads full-scale – that is, 1 volt.

2.
With a constant input signal, change the frequency to 100 kHz and adjust trimmer C472 in the attenuator for a meter reading of 1 volt.

3.
Repeat the procedures described under 1 and 2 above until the same reading is obtained for 1 kHz and 100 kHz.

Adjusting the Built-in Calibration Generator (CAL. GEN.) by Means of a Voltage Calibrator.

When the instrument has been calibrated by means of the external voltage calibrator, turn on the built-in CAL. GEN. and adjust R102 on the main circuit board for 1.000 volt as measured at the RMS OUTPUT terminal.

TROUBLE SHOOTING

(1)
First check to make sure that the trouble is not a result of conditions external to the RMS Voltmeter.

(2)
Check, visually, the RMS Voltmeter for burned or loose components, loose connections, or any other condition which might suggest a source of trouble.

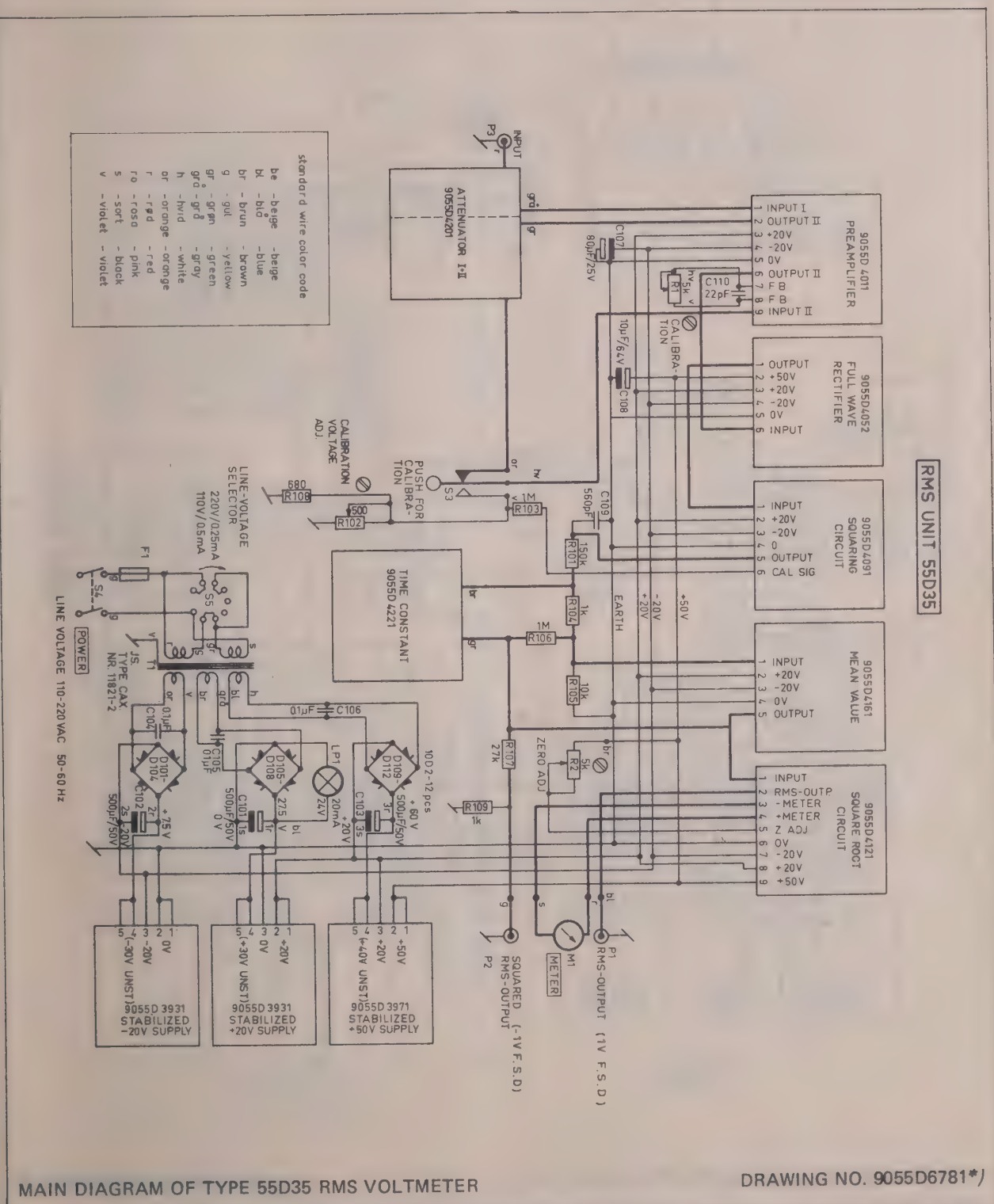
(3)
Check and adjust, if necessary, the instrument as described in the section *Adjusting the RMS Voltmeter*. This step-by-step procedure may now be used as a guide in locating causes of trouble.

(4)
The procedure outlined does not cover all circuit parameters and can only be used to localize the circuit or circuits responsible for malfunctioning. It is quite possible, therefore, that additional measurements will be required to pinpoint the source of the trouble.

(5)
In order to facilitate additional check measurements, the most important voltages are listed in the circuit diagrams. Because of slight differences between individual instruments, exact duplication of values and waveforms should not be necessary.

Unless otherwise indicated, voltages in the circuit diagrams should be measured without signal at the INPUT terminal (INPUT terminal short-circuited).

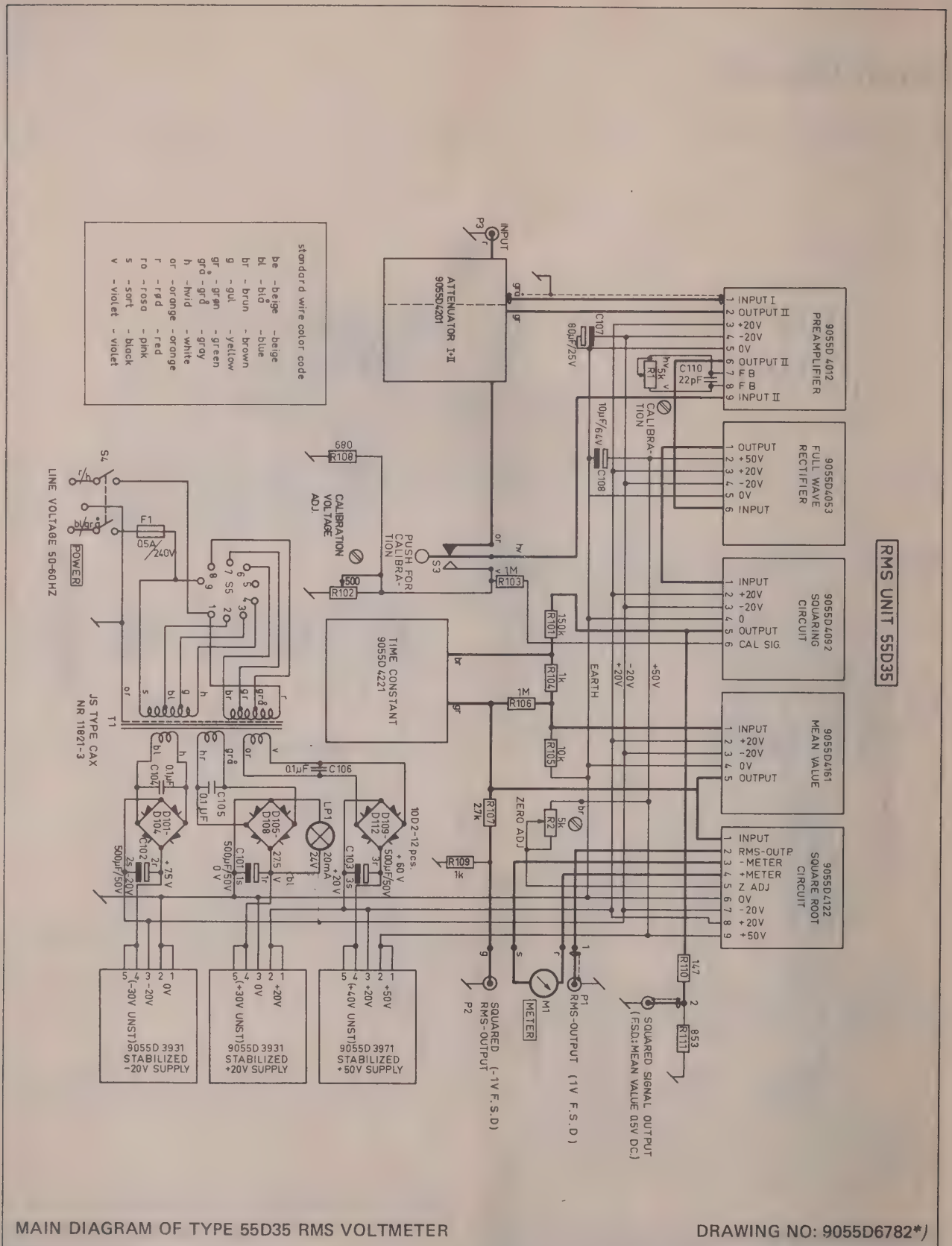
Circuit Diagrams



MAIN DIAGRAM OF TYPE 55D35 RMS VOLTMETER

DRAWING NO. 9055D6781*)

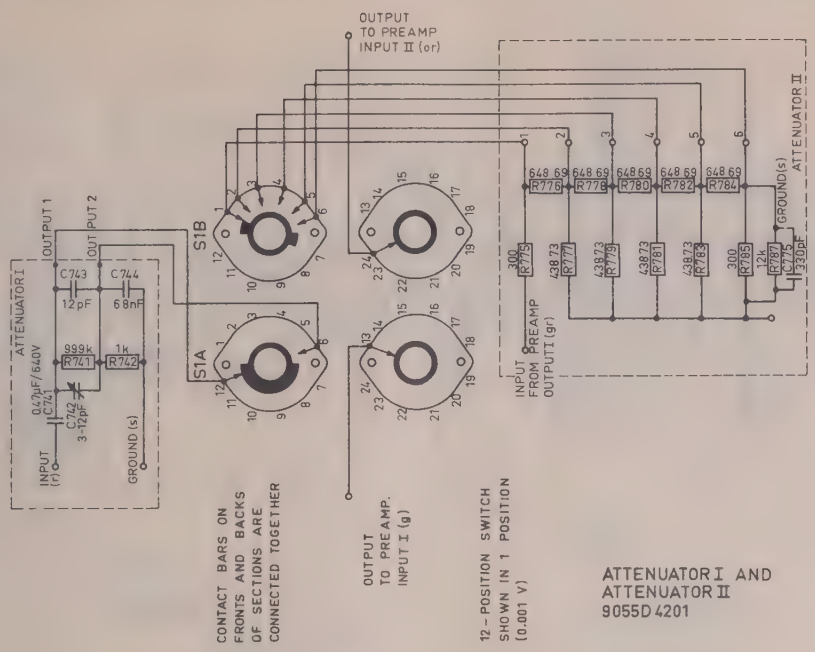
*) *only for MARK I.*



MAIN DIAGRAM OF TYPE 55D35 RMS VOLTMETER

DRAWING NO: 9055D6782*)

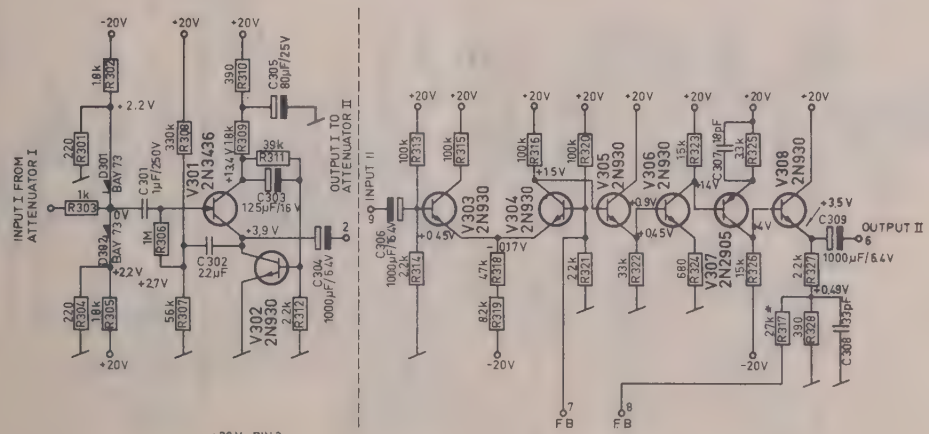
*) only for MARK II



ATTENUATOR I AND ATTENUATOR II OF TYPE 55D35

DRAWING NO. 9055D6871*)

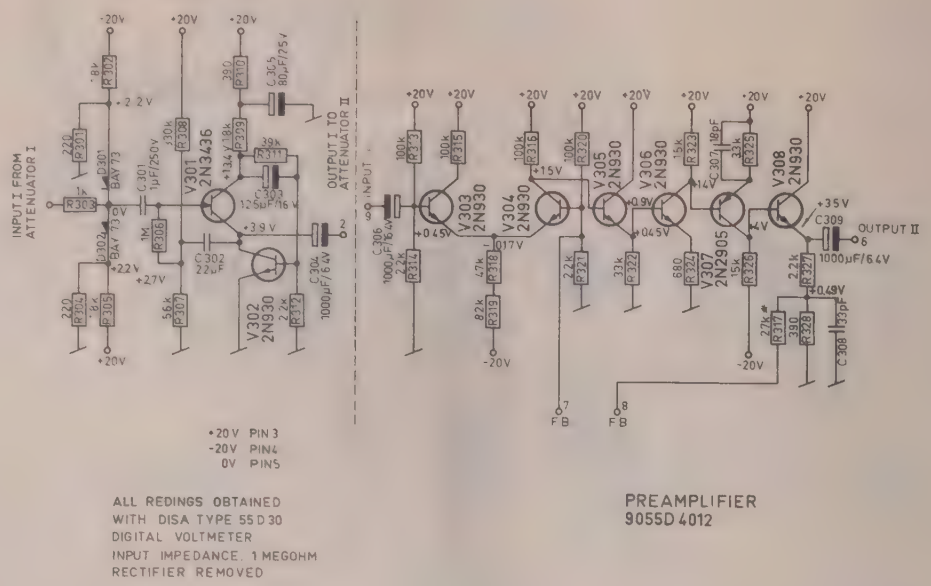
*) *for MARK I and MARK II*



PREAMPLIFIER OF TYPE 55D35

DRAWING NO. 9055D6811*)

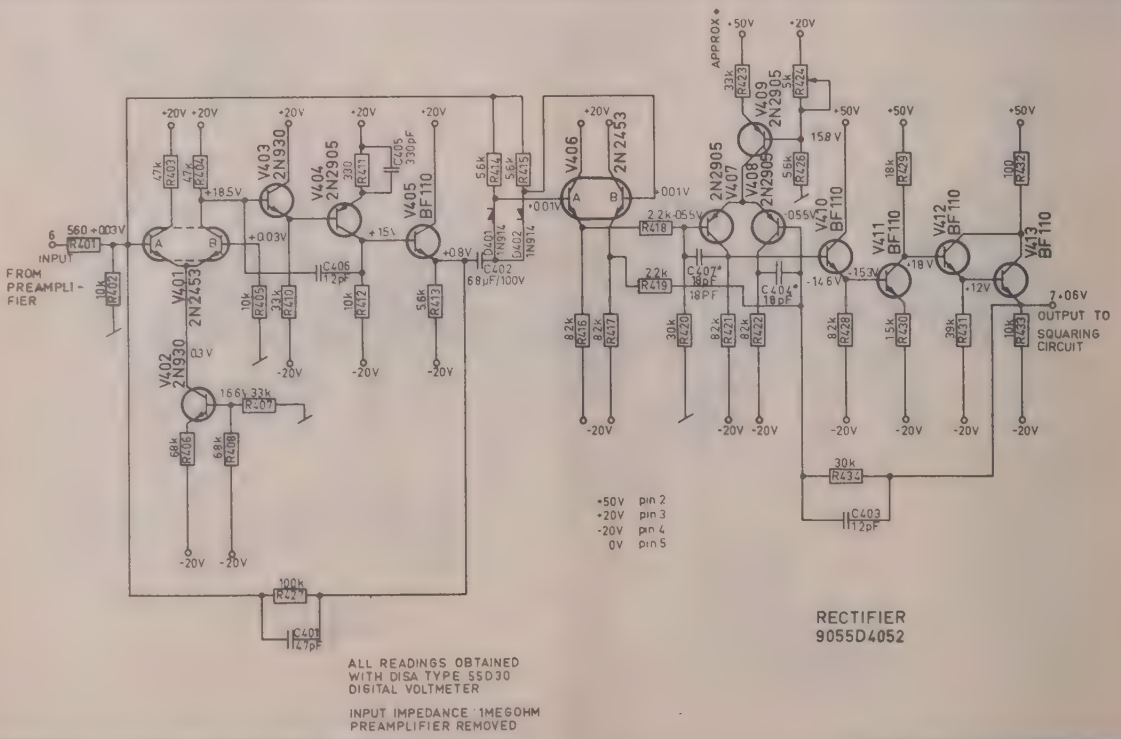
*) *only for MARK I*



PREAMPLIFIER OF TYPE 55D35

DRAWING NO. 9055D6812*)

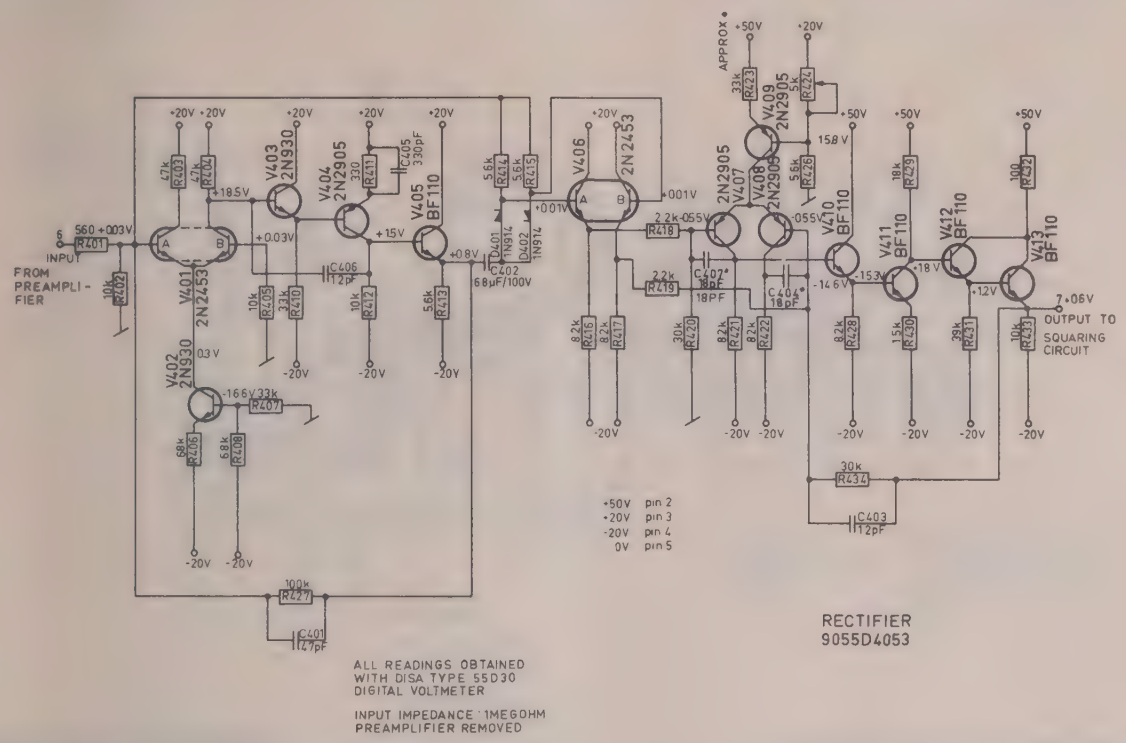
*) *only for MARK II*



FULL-WAVE RECTIFIER OF TYPE 55D35

DRAWING NO. 9055D6822*)

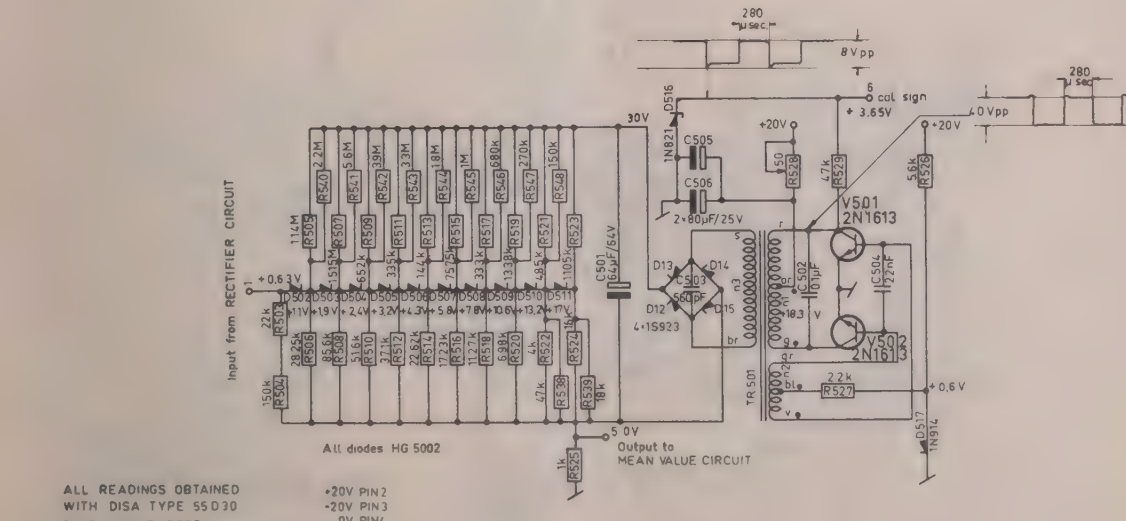
*) *only for MARK I*



FULL-WAVE RECTIFIER OF TYPE 55D35

DRAWING NO. 9055D6823*)

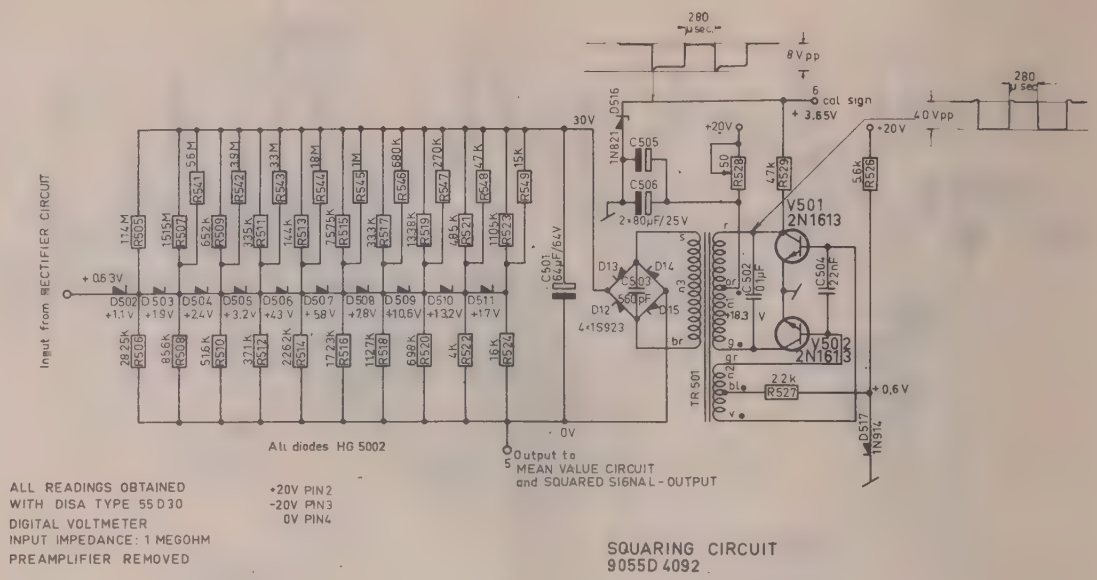
*) only for MARK II


Input from RECTIFIER CIRCUIT
All diodes HG 5002
Output to MEAN VALUE CIRCUIT
ALL READINGS OBTAINED WITH DISA TYPE 55D30 DIGITAL VOLTMETER INPUT IMPEDANCE 1 MEGOHM PREAMPLIFIER REMOVED
+20V PIN2
-20V PIN3
0V PIN4
SQUARING CIRCUIT 9055D 4091

SQUARING CIRCUIT OF TYPE 55D35

DRAWING NO. 9055D6831*)

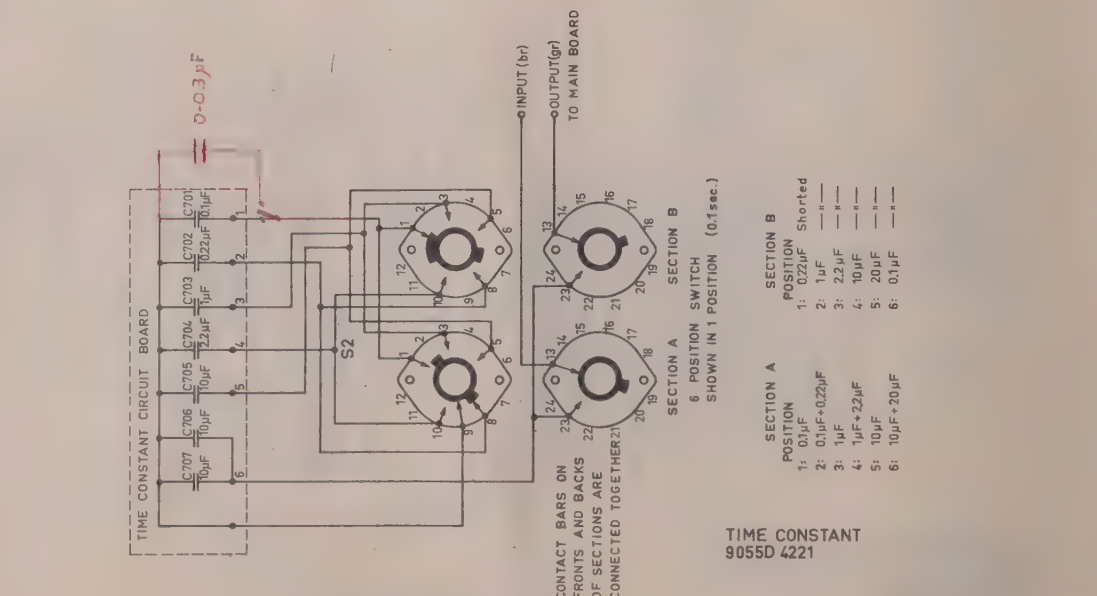
*) only for MARK I



SQUARING CIRCUIT OF TYPE 55D35

DRAWING NO. 9055D6832*)

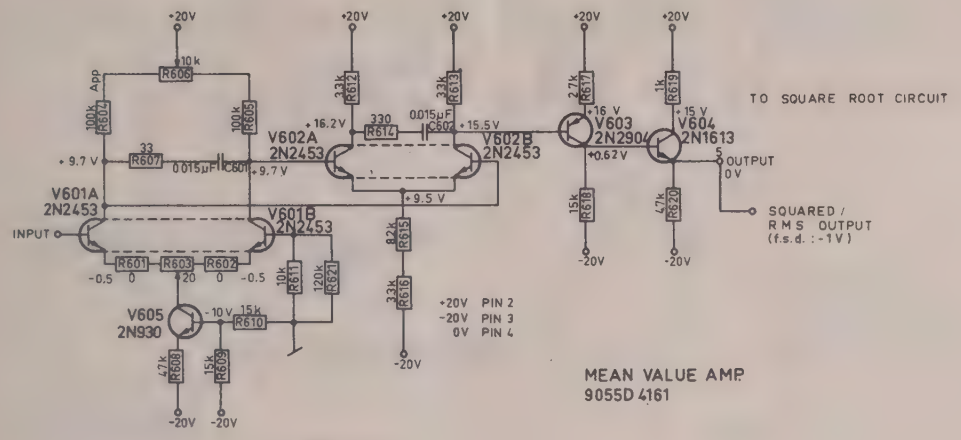
*) *only for MARK II*



TIME CONSTANT OF TYPE 55D35

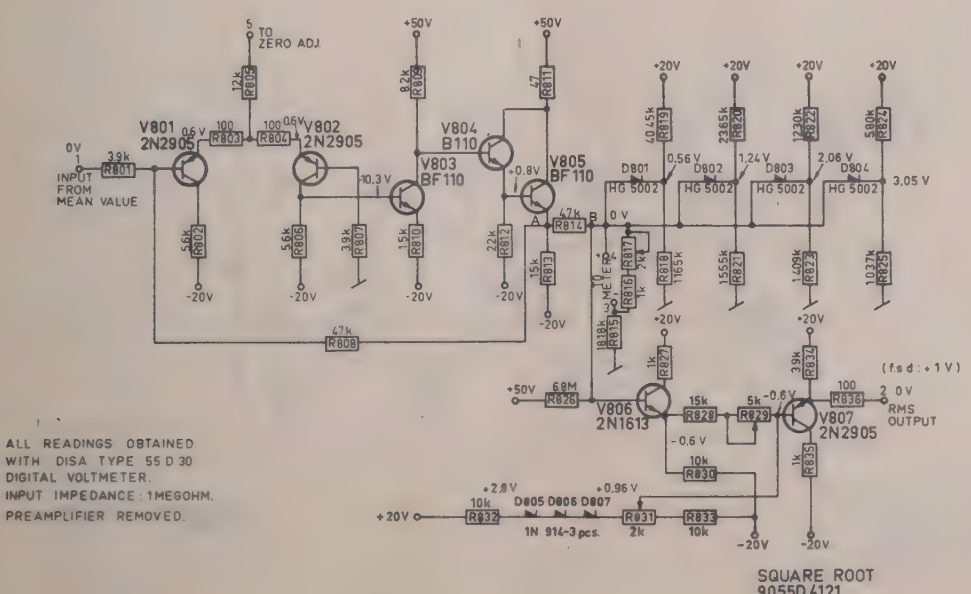
DRAWING NO. 9055D6861*)

*) *for MARK I and MARK II*



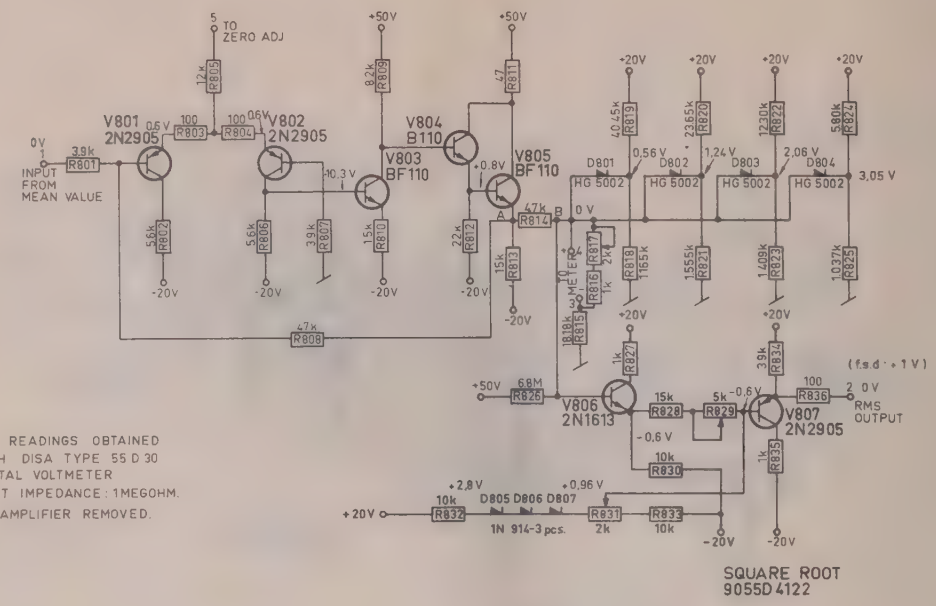
MEAN VALUE AMPLIFIER OF TYPE 55D35 — DRAWING NO. 9055D6851*)

*) *for MARK I and MARK II*



SQUARE ROOT CIRCUIT OF TYPE 55D35 — DRAWING NO. 9055D6841*)

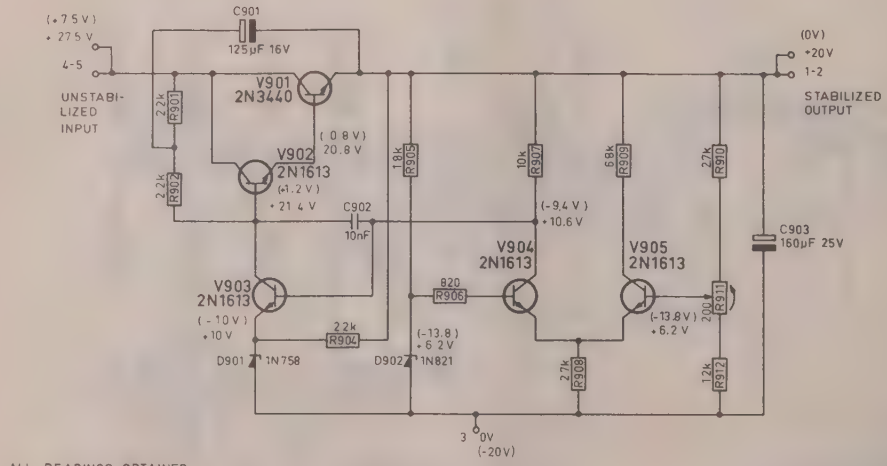
*) *only for MARK I*



SQUARE ROOT CIRCUIT OF TYPE 55D35

DRAWING NO. 9055D6842*)

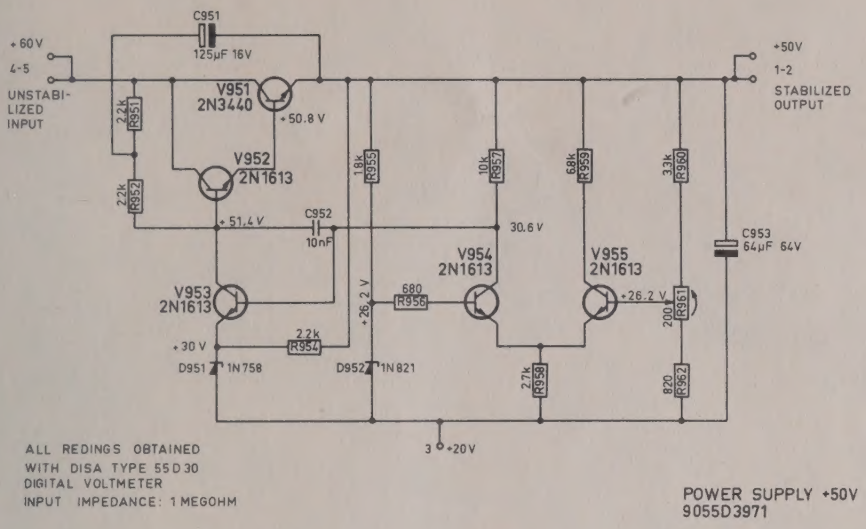
*) only for MARK II



STABILIZED +20- AND -20-VOLT POWER SUPPLIES OF TYPE 55D35

DRAWING NO. 9055D6791*)

*) for MARK I and MARK II



STABILIZED +50-VOLT
POWER SUPPLY OF TYPE 55D35

DRAWING NO. 9055D6801*)

*) *for MARK I and MARK II*

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